Universal Design as an Approach to Technology Intervention for Seniors

Jon A. Sanford(✉)

Center for Assistive Technology and Environmental Access, Georgia Institute of Technology, Atlanta, GA, USA
jon.sanford@coa.gatech.edu

Abstract. Typical design approaches for technology interventions for seniors tends to focus on specialized design to accommodate functional limitations associated with either disability or aging. This paper will propose universal design as an alternative approach that focuses on design for all users, regardless of age or ability. Moreover, while specialized design is based on prescriptive requirements that often dictate what to design, universal design is an approach to technology intervention that is guided by a set of performance principles and guidelines that provide a rationale for how to design technologies. As such, universal design as extends the usability of everyday design to seniors, without the need for special adaptations or devices.

Keywords: Universal design · Design for aging · Specialized design · Technology for seniors

1 Introduction

Much has been written about the design of assistive and other types of technology interventions as a rehabilitation strategy to facilitate health, activity and participation of individuals with a variety of impairments and disabilities. Similarly, much has been written about the design of technology interventions as a strategy to promote aging in place by seniors undergoing the normal aging process. However, little consideration has been given to universal design as an approach for technology intervention for seniors who are experiencing both disability and age-related declines in function. The reason is simple, universal design is typically viewed as incompatible with the fundamental goals of rehabilitation and design for aging technologies (Nichols et al. 2006). Whereas these approaches are specialized designs tailored to needs of individuals or groups of individuals with either impairments or age-related deficits, or both, universal design is not intended specifically for older adults or those with impaired function. Rather, it is design that is usable by all people to the greatest extent possible without the need for adaptation or specialized design (Mace et al. 1991). As Steinfeld (1994) pointed out, these differences are not simply semantic. Specialized design typically results in separate designs for people with functional limitations, while universal design provides one design solution that can accommodate people with disabilities and limitations as well as everyone else.

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Although universal design may be conceptually appealing, this paper recognizes that it is a utopian design philosophy that is not technically achievable in the design of hardware, which has a fixed form, although more likely achievable with software, which has a more fluid form. Nonetheless, universal design imagines what a world should be, not necessarily what the world will be. As a result, the contribution of this paper is in providing technology designers with a new way of thinking about interventions for seniors.

2 Types of Interventions

Technology can be, at the same time, prosthetic and therapeutic, compensating for limitations in functional abilities and enabling health maintenance and management. As a prosthetic, technology interventions for seniors can facilitate basic activities associated with safe and independent living, participation in social roles and provision of personal assistance from caregivers as needed. Therapeutically, it can facilitate health promoting behaviors and provision of healthcare services.

2.1 Specialized Technology as a Prosthetic Intervention

To remove or overcome barriers to performance of routine tasks and activities by people with disabilities and age-related limitations specialized "accessibility" technologies have traditionally been added to (e.g., voice over and high contrast screens) or replaced (e.g., devices with large simplified, large font keypads or augmentative communication devices) everyday designs. Acting as facilitators that address barriers created by the design of everyday technologies, specialized designs serve as prosthetic supports that facilitate the performance of everyday activities by compensating for disability and other limitations in ability. With the assistance of specialized designs individuals with a variety of limitations are able to carry out basic activities associated with daily living safely and independently and receive personal assistance from caregivers that would otherwise not be possible.

Nonetheless, specialized technologies are solely intended to enhance the performance of individuals with functional limitations, not of the general population (Sanford 2012). They are, by nature, reactive approaches that are added on to everyday designs or are specialized designs only for those who need it. Thus, despite their role in enabling activity by people with functional limitations, they are often associated with the stigma of disability, and as such are not used by seniors who do not see themselves as being "disabled."

However, people are growing older and a larger number of individuals are living longer with disabilities. Not surprisingly, a considerable amount of research over the past three decades has shown that the traditional specialized design approach does not adequately compensate for the range of age-related comorbidities and secondary conditions, including limitations in strength, stamina, reach, dexterity and fine motor control, lifting legs and sit-to-stand, loss of contrast sensitivity and visual acuity, memory loss and diminished cognitive functioning, and hearing loss that are common among seniors. As a result, specialized design, which is intended to promote accessibility, neither ensures usability, but may do more to promote excess disability among older people than to ameliorate it (Sanford et al. 1999; Sanford and Megrew 1995). Similarly, specialized design, which is intended to promote independent functioning, may not be adequate for seniors who are often dependent in one or more basic activities of daily living; or for their spousal (i.e., also aging) caregivers, for whom accessible design is not intended. These suggest that a more universal approach based on the needs and capabilities of a wider range of individuals is warranted.

2.2 Health Technology as a Therapeutic Intervention

By 2015 an estimated 150 million Americans will have at least one chronic condition due to a variety of causes such as congestive heart failure, cardio pulmonary diseases, deterioration in musculoskeletal system and connective tissue, and injury (Wu and Green 2000). With the increase in chronic health conditions there has been a dramatic increase in the level of care requirements including the need to engage teams of multiple physicians, specialists and formal and informal caregivers. As a result, chronic diseases account for 75 % of all U.S. healthcare costs (Scheschareg 2005).

As the intensity and cost of chronic care has increased, the use of personal health technologies, particularly in the home environment has played an ever-expanding role in health management and prevention. With the dramatic increase in home care services provided by Medicare in the past two decades, the boundary between hospital and home has become blurred (Binstock and Cluff 2000). This growth has not only been fueled by a desire for reduced lengths of stay and controlling cost, but also by a variety of new home-based therapeutic products and technologies that support aging in place through more active care management and passive monitoring of safety and activity.

By placing a greater emphasis on prevention and wellness than on acute care, home-based technologies are changing the way health care is provided to seniros and the way in which the home environment is utilized and conceptualized. Such technologies enable family members and health care providers to manage and promote health by: (1) actively monitoring health status (e.g., vital signs, weight, and oxygen saturation) that requires engagement of individuals to manage own their care; (2) passively monitoring activity (e.g., bathing, toileting, eating, medication adherence, and physical movement), and potential safety hazards (e.g., turn off stove burners, maintain water temperature to prevent scalding, adjust lighting levels to prevent falls risks, detect smoke and lock doors to prevent wandering of individuals with dementia) through sensors, transmitters, and receivers embedded in the environment (e.g., woven into carpet); and (3) promoting interactive communication with social networks and clinicians via cell phones, videophones, internet, television, camcorders, and communications software to enhance both psychological and physical health.

Like specialized designs, medical devices and technologies can have a large impact on the home environment and on the individuals living there. Many healthcare devices and technologies were developed for institutional settings, which are very different in size and appearance than residential settings. Moreover, they these devices and technologies were designed to be used by trained healthcare professionals not lay consumers. As a result, technologies often exceed the skills and abilities of seniors. Of equal importance in residential environments is aesthetics. Devices that look institutional are neither compatible with residential settings, nor do they consider the personal needs and tastes of the residents. This not only creates stigma, but leads to disuse and abandonment.

3 Universal Design as a Technology Intervention Strategy

Conceptually, universal design does not view disability as a single point requiring specialized technology intervention, but a segment of the continuum of ability that benefits from usability and inclusivity to promote positive activity and participation outcomes, respectively (Sanford 2012). Rather than focus on limitations in ability, the appropriate focus of universal design is on the range of human performance characteristics that are shared by all and experienced across our lifespans. Thus, universal design not only facilitates performance for an individual at any point in time, but also at any point across an individual's lifespan.

Universal design of technology for seniors is radically different from specialized technology design both conceptually and in physical form. Conceptually, specialized design is an add-on component or special "senior" design to remove the barriers created by the misfit between everyday design and seniors with functional limitations. In contrast, universal design is an integral component of everyday design that addresses barriers from the very beginning of the design process. As such, universal design supports the broadest range of types and levels of all abilities for all individuals, regardless of age, stature or physical function. These qualities are captured by and articulated in the Principles of Universal Design (Connell and Sanford 1997).

4 The Principles of Universal Design

With support from the National Institute on Disability and Rehabilitation Research, ten leading proponents of universal design, including architects; industrial, landscape, and graphic designers; and engineers developed the 7 Principles of Universal Design (Table 1) to define the general performance goals and guidelines for universal design. Although the Principles have never been validated and are too generic to apply as design criteria, in less than a decade they had been translated into a number of different languages and reprinted on hundreds of websites around the globe. Despite their shortcomings, the Principles are useful for guiding and evaluating the usability and inclusivity of technology interventions for seniors.

4.1 Equitable Use

Design of technology should be equally usable by and marketable to everyone. It should avoid segregating and stigmatizing users, and it should provide the same means of use for everyone. When possible means of use should be identical (e.g., the same

Table 1. Principles of Universal Design (Connell 1997)

Principle 1. Equitable Use: The design is useful and marketable to people with diverse abilities.
1a. Provide the same means of use for all users: identical whenever possible, equivalent when not.
1b. Avoid segregating or stigmatizing any users.
1c. Provisions for privacy, security, and safety should be equally available to all users.
1d. Make the design appealing to all users.
Principle Two: Flexibility in Use: The design accommodates a wide range of individual preferences and abilities.
2a. Provide choice in methods of use.
2b. Accommodate right- or left-handed access and use.
2c. Facilitate the user's accuracy and precision.
2d. Provide adaptability to the user's pace.
Principle Three: Simple and Intuitive Use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
3a. Eliminate unnecessary complexity.
3b. Be consistent with user expectations and intuition.
3c. Accommodate a wide range of literacy and language skills.
3d. Arrange information consistent with its importance.
3e. Provide effective prompting and feedback during and after task completion.
Principle Four: Perceptible Information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
4b. Provide adequate contrast between essential information and its surroundings.
4c. Maximize "legibility" of essential information.
4d. Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
4e. Provide compatibility with a variety of techniques or devices used by people with sensory limitations.
Principle Five: Tolerance for Error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
5b. Provide warnings of hazards and errors.
5c. Provide fail-safe features.
5d. Discourage unconscious action in tasks that require vigilance.
Principle Six: Low Physical Effort: The design can be used efficiently and comfortably and with a minimum of fatigue.
6a. Allow user to maintain a neutral body position.
6b. Use reasonable operating forces.
6c. Minimize repetitive actions.
6d. Minimize sustained physical effort.
Principle Seven: Size and Space for Approach and Use: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.
7a. Provide a clear line of sight to important elements for any seated or standing user.
7b. Make reach to all components comfortable for any seated or standing user.
7c. Accommodate variations in hand and grip size.
7d. Provide adequate space for the use of assistive devices or personal assistance.

hardware and software), when not possible, equivalent means should be available (e.g. the same hardware, with different or customizable interfaces). Universal design features should be integrative and inclusive. In this way, universal design is everyday design, appealing to everyone, not just people who need special design features.

4.2 Flexibility in Use

Technology design should accommodate a wide range of individual preferences and abilities. It should also be forgiving, providing choices in methods of use. At the scale of interface control, use of multimodal input/output (I/Os) (e.g., touch, voice, physical buttons) and navigation (e.g., touch buttons, scroll, and swipe gestures) methods enable an individual to choose according to need and ability. Similarly, interfaces should also be tolerant and forgiving of different abilities by adapting to a user's levels of precision, accuracy and pace, such as physical inputs that minimize exactitude (e.g., large touch buttons separated by sufficient space), visual information that requires little acuity (e.g., large text size, high color contrast) and audio information that has variable speed and volume. At the level of flexibility of interfaces, software enables the design of multiple or customizable interfaces with choices of I/Os to be used with the same hardware.

4.3 Simple and Intuitive Use

Regardless of the user's experience, knowledge, language skills, or level of concentration, interfaces should be easily understood. In addition, the information should be intuitive, obvious and spontaneous, even if an individual has never encountered that design before (e.g., yes/no responses, widely recognized icons for text size, audio speed, contrast, up and down arrows). To accomplish this, interfaces should eliminate unnecessary complexity (e.g., multiple screens or dropdown menus to control visual clutter), present information in a manner that is consistent throughout the application (e.g., the same input controls in the same place on each screen) and with its importance (e.g., on/off button on top) and provide prompting (e.g., visual and verbal queries) and feedback (e.g., auditory response or visual acknowledgement) to respond to inputs.

4.4 Perceptible Information

To effectively communicate information to users who have different abilities to see, hear and understand, interface design should use as many different modes (e.g., pictorial, text, verbal, tactile) as possible. Devices should integrate simultaneous visual and audio output as a default, rather than using separate outputs that require that the audio be turned on. In addition, touch screen buttons should provide redundant visual cues through color, icons, and text.

Regardless of the mode used, design should maximize "legibility" of the essential information by providing large/adjustable font sizes, adequate (e.g., visual, auditory, cognitive) contrast between the essential information and the background, differentiating elements in ways that can be described (i.e., make it easy to give instructions or directions, such as "push the red button first") and enabling users to use any assistive devices, such as low vision or hearing aids, that they might require to obtain information. Finally, tactile information should be integrated into the hardware to help locate inputs on non-tactile digital interfaces.

4.5 Tolerance for Error

Errors can result in both a risk to personal safety (e.g., communicating wrong medical information or not pushing the right button in an emergency) as well as inadvertent mistakes that can lead to loss of time and frustration (e.g., hitting the delete button). As a result, technology design should minimize hazards and unintended actions that could have adverse outcomes. To do so, unconscious actions in tasks that require undivided attention (e.g., communicating medical information) should be discouraged by using of fail-safe features, such as locating contradictory input buttons (e.g., yes/no, accept/delete) far apart; providing warnings and verification queries to confirm a selection or identify mistakes; and arranging elements so that those that are most important are most accessible and those that are least important are omitted or protected (e.g., menus and help buttons) at the top and forward/back buttons at the bottom. Finally, page sub-review and final review options should be provided to ensure that all inputs are as intended.

4.6 Low Physical Effort

Ease of use is perhaps the one quality that is most commonly associated with usability. However, Principle 6 goes beyond simple ease/difficulty to include performing tasks efficiently, comfortably and with minimal fatigue. To accomplish these outcomes, the design should locate the primary input buttons and use gestures that will enable the user to maintain a neutral body position; minimize strength and stamina by enabling use of low (or no) operating forces, such as using digital touch vs. physical buttons; minimizing the need to apply sustained force (e.g., voice input); and minimizing repetitive and simultaneous actions without resting, such using a single tap vs. a double tap.

4.7 Size and Space for Approach and Use

Size and space for interface design includes the visibility (both visual and tactile), location and size of targets on the screen to permit use by individuals with a range of visual and dexterity abilities. For example, placing large buttons in the corners or the edges of the screen enhance visibility for blind or visually-impaired users. In addition, large targets can enable components to be reached comfortably by users with limited reach or dexterity.

5 Discussion

Adopting universal design as a viable technology intervention strategy for seniors requires discarding current, yet outdated 20th Century paradigms that favor specialized interventions for identified groups over those that promote functionality for everyone. Despite the technical success of traditional specialized technology intervention strategies in increasing function for individuals, they have, on the one hand, promulgated the proposition that being able to perform an activity would enable seniors to successfully age in the community, while creating stigmatizing and segregating devices, on the other. In contrast, universal design is rooted in a more integrative paradigm that makes function and functionality (i.e., usability and inclusivity) the design norm rather than the exception. By integrating specialized design into everyday technology, universal design is not just hard to see, it is invisible.

This idea of intervention invisibility is clearly not an outcome with which rehabilitation and design for aging practices are familiar. It clearly requires a paradigm shift from one that is emboldened by a set of *prescriptive rules* of *what to do* to a set of *performance guidelines* (i.e., Principles of Universal Design) that define *why it should be done*.

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